Hydropower and Fish –Report and messages from workshop on research and innovation in the context of the European policy framework

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Abstract

Hydropower is the world's largest renewable electricity source and will have an important role in the future energy system with increased requirements to integrate environmental and socioeconomic aspects of sustainability. One important field of interaction is between hydropower and fish. The aim of optimizing hydropower production as well as fish production via Research and Innovation in the context of the European policy framework was the topic of the workshop "*Hydropower and Fish – Research and Innovation in the context of the European Policy Framework*" organized in May 2017 in Brussels. This paper reports the main messages from the workshop sessions including future research needs, collaboration strategies and knowledge exchange. In particular, the workshop emphasized the need for standardized monitoring and mitigation approaches and of following balanced approach in addressing challenges between renewable energy production and river and fish ecology. Future research in the area is needed. As perspective and primer for future discussions, the interrelations of hydropower and fish to the different spheres of the total environment are presented and discussed.

Introduction

This is the accepted version of an article published in Science of the Total Environment
DOI: 10.1016/j.scitotenv.2018.08.054

Increased awareness of ecological issues (e.g. for fish population ecology), and the multidisciplinary scientific progress on rivers with regulated water flows, calls for a comprehensive understanding and information exchange through research and innovation and in the context of policy and operational practice. The given anthropogenic multipurpose use of European river systems, and in particular, the increasing demand for renewable energy within a changing energy system emphasizes the importance for sustainable hydropower industry.

Fragmentation of rivers due to hydropower regulation is a main reason for the decline and reduced distribution of freshwater fishes (Nilsson et al. 2005). Potential challenges between hydropower production and fish and river ecology can arise through direct impacts on the river systems, like blocking of migration corridors, physical habitat degradation, alternation and diversion of flow and sediment transport alteration. Sustainable hydropower production tries to mitigate these impacts and from a total environment perspective a research and knowledge-based approach could help to avoid or resolve any potential conflicts between hydropower and fish and between the different spheres of the total environment (see. figure 1). New technologies and knowledge can help to better understand the impacts and respective mitigation measures. In this context, important advances are made on fish monitoring, system modeling, fish passages, hydroelectric turbines and fish protection technology, while changes to the ecological river system might occur for example through climate issues, changes in river water quality and changing requirement of the energy system.

In May 2017 a workshop "*Hydropower and Fish – Research and Innovation in the context of the European Policy Framework* was organized by the International Energy Agency's Technology Collaboration Programme on Hydropower (IEA Hydropower TCP / IEA Hydro) and the Directorate General for Research and Innovation of the European Commission (EC DG RTD). The workshop was held in Brussels to address the European research and legislation

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relevant for hydropower production and development and to highlight its impacts on fish populations (for presentations, see IEA Hydro, 2017). The workshop was followed by a field excursion to the Ham hydropower plant on the Albert Canal with its new dual-use fish passage system at a lock on the Albert Canal, a relevant example on how viable fish communities can be maintained in a river system heavily exploited for navigation, water supply and hydropower production.

Delegates with diversified scientific, technical or policy background represented European hydropower operators, researchers, managers, policy makers, regulatory bodies and NGOs. Centered on the European river systems and the underlying European policy framework the discussions brought together important aspects and impacts on the topic of hydropower and fish (Figure 1). The workshop covered with its set agenda, presentations and discussions the involved parts of the hydrosphere (e.g. sediments, hydromorphology, hydropeaking), biosphere (fish habitat and fish migration) and anthroposphere (hydropower technology, energy and climate goals, renewable energy framework, and the EU water framework directive (WFD)). On one hand, there is strong and growing demand for renewable and more flexible energy supply, and in this case hydropower, across the world. On the other hand, fish ecology and riverine habitats are often strongly and negatively impacted by hydropower plant development.

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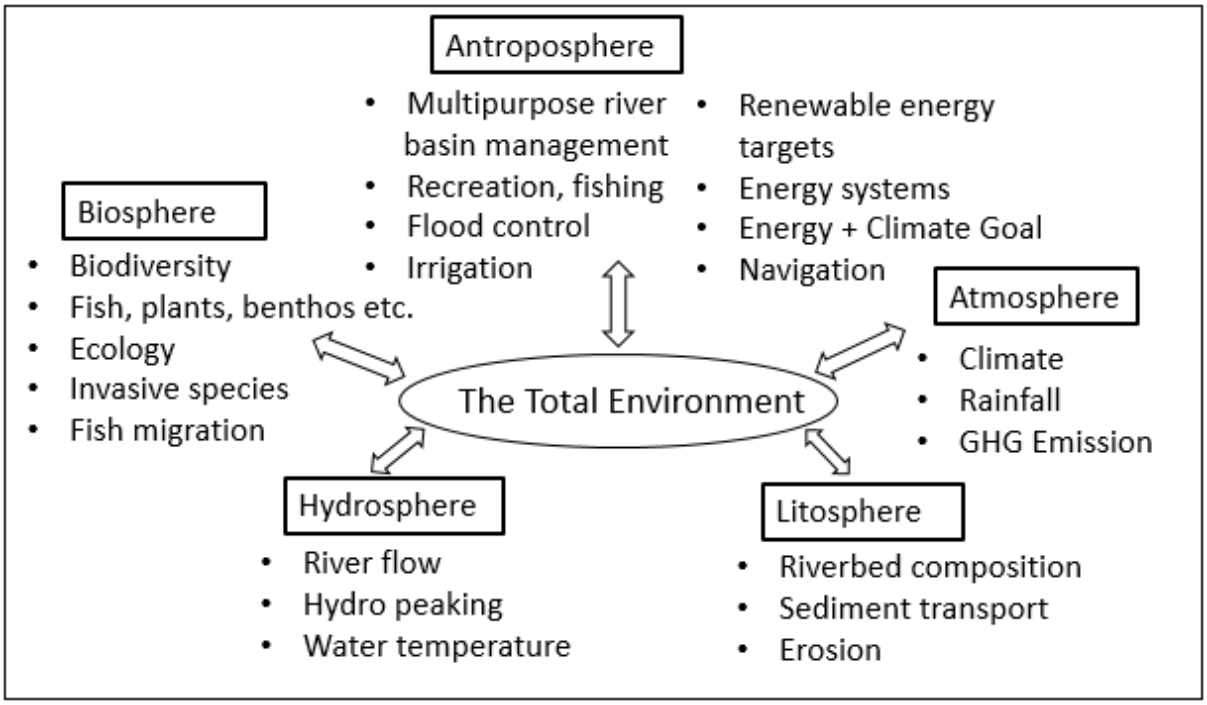

Figure 1. Interfaces of hydropower and fish to the different spheres of the total environment

With the goal of all the value chain actors to overcome present challenges and conflicts, current research results were presented in thematically diverse sessions (Table 1) and future research needs were crystalized out in the final panel discussion concluding the workshop.

Table 1. List of session topics of the workshop

Session	Title
1	The EU Water Framework Directive- the Legislative Context
2	The EU Water Framework Directive -National legislations and implementation
3	Hydropower and Fish in the context of Research and Innovation
4	Hydropower, Fish Technology
5	Fish habitat in regulated rivers
6	Migration and River connectivity
7	Energy and ecology

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Panel Discussion

Workshop themes

"*Where do we go from here?*" This was the question posed by Piotr Tulej, head of the Unit Renewable Energy Sources at the European Commission DG RTD, responsible for hydropower research within the EU Framework Programme for Research and Innovation, Horizon 2020 (see HORIZON 2020), in his speech opening the workshop. Scope, objectives and tools of the WFD were presented, highlighting the important function of the WFD as a driver for research and innovation and the need for increased coordination, integration and collaboration of all involved subjects and respective stakeholders. Speaking to representatives from more than 20 European countries, key issues for research and innovation and ongoing activities in the Horizon 2020 Societal Challenge 3 Energy Work Programme were outlined. Europe is a world leader in hydropower technology development and representing a mature renewable technology, though the hydropower sector does face long-term challenges which requires continuous efforts for resolution. Torodd Jensen, Chair of the Executive Committee of IEA Hydro set the scene by highlighting the societal impact of hydropower regarding multipurpose uses, e.g. flood control and grid balancing of variable renewables. Further topics regarding biodiversity, environment and hydropower, and its role within the European Energy Union Framework were elaborated in further presentations.

Framed by the European legislative context of the WFD the workshop brought together representatives from many of the large European research programs under the Horizon 2020 umbrella, such as SEDNET, AMBER, FIThydro and HYPERBOLE (see CORDIS). New innovations were presented, demonstrating the wide and important range of technologies for total environment monitoring. Some of the more unusual and innovative techniques included data sampling using drones and robotic fishes as well as innovative big data approaches.

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National implementation of the WFD were presented for Austria, where a large number of hydropower installations deliver more than 60% of the national electricity production. Indeed, fish are affected by hydropower and two thirds of Austrian fish species are endangered. The Austrian strategy for the National River Basin Management centers around minimizing negative impacts on aquatic ecology, strategic planning (e.g. site selection) through research and innovation to increase the knowledge base and to find balanced solutions both for river ecology and for hydropower production.

Further show cases for national policy implementation were presented from Finland and Norway and the Swiss and Italian regulatory context was presented from an operator's perspective, revealing that given their hydropower particularities national management policies differ widely among the European countries. Some of the mentioned differences were:

- The national energy system
- River system characteristics and regional properties, such as topography and fish communities.
- Research traditions
- National status for synchronization of European legislation

Partly, this situation was debated as a disadvantage because it limits the desired use of common protocols and the utilization of existing knowledge spread within the European community. Hence, the need for common indicators was clearly highlighted.

Another presentation highlighted the role of storable hydropower in Europe that may change as a result of the rapid speed of wind and solar energy penetration in the continent’s power network. The more dynamic production schemes required for hydropower operations lead to rapid changes in river flow, which can have negative ecological impacts, such as habitat loss,

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particularly for fish. The consequences of such so-called hydropeaking were highlighted as a main future research area in several presentations. Approaches for integrated hydropeaking management, the interaction between hydropeaking and hydromorphology and the interaction between hydropeaking and ecological flow were assessed in different presentations and it was a clear view that more knowledge and common rules for hydropeaking procedures should be developed, also considering the economic necessities. Future research needs were also outlined in the fields of sediment research. One of the project messages is that sediment transport, and sediment transport disruption, must be regarded as an essential, dynamic and integrated part of river basin management in regulated rivers. One presentation challenged hydropower development as the major threat to biodiversity, including impacts on fish migration, impacts from hydropeaking, sediment flow, habitat alterations as well as alien species invasion promoted by reservoirs and diverted rivers.

Other important research topics presented included strategies for ensuring the safe downstream migration of fishes past hydropower structures and turbines, and monitoring approaches to assess fish pass efficiency. Solutions discussed included hydropower turbine technology and mitigation measures and the importance of integrated field survey and modeling was clearly shown. Overall, there was a focus on river connectivity along entire catchments and river basins, instead of single, isolated projects.

Standardized monitoring and mitigation approaches

Based on the discussions at the workshop, we emphasize the need for Europe-wide standardization of monitoring programs and mitigation measures for hydropower impacts in order to better understand and assess the impacts of management actions. One key aspect of

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this is to develop standardized approaches to assess residual flows and environmental flows in rivers affected by hydropower developments. The expression “environmental requirements” must be emphasized, underlining that not only fish, but overall biodiversity, is important to fulfill the requirements of the WFD.

In recent decades, a variety of modelling tools have been developed to describe the different impacts from hydropower on fish. One important message from the workshop was that modelling tools should be included in the management suite in order to achieve realistic goals. Such approaches need to be scalable from single topic models to holistic analyses of large river catchments (see for example Poff et al., 2010). The authors advocate this as crucial, because many fishes migrate over long distances across political and management borders. Discussions also highlighted the importance of timely implementation of existing research and available knowledge gained by research on hydropower impacts, not to wait for a definite solution which may never come. Important in this respect is also species-specificity of parameters, such as fish behavior in front of hydropower turbines in respect of mitigation measures, fish size, reproductive age, and different habitat requirements as shown on the example of sturgeon with their large size and particularly long reproductive life cycle.

Balancing perspectives on water management for hydropower and fish

Overall, discussions at the workshop highlighted that future research, policy and management on hydropower and fish must seek to find a balance between renewable energy production, and the ecological health and status of impacted rivers in Europe. The importance of research and innovation, being it technology developments or in providing knowledge and data for better informed decision making in an integrated approach targeting at the same time hydropower economy and multipurpose use, hydro- and biosphere ecology was defined as a clear requirement for further general improvement and targeted management solutions. While future

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research and data availability can help to optimize the relationship between hydropower production and fish production and protection, equally important is the constant dialogue between the stakeholders of the different value chains for deriving a common understanding of respective economic, social and environmental sustainability constrains. In the future, both research and information exchange can help to co-optimize hydropower production and fish production and protection as well as other uses of the European river basin systems, like, navigation, flood control or irrigation needs.

The Panel discussion underlined the timeliness and importance of the workshop as well as the added value of comparing and exchanging results across Europe. We suggest that a better cooperation in this context should allow for better results by fostering synergies between national and European research programs and national management policies. The WFD is an important instrument in stimulating water management in the context of energy, climate change and water management as well as the importance of international information sharing and cooperation. The importance of establishing relevant baselines and introducing a standardized form of reporting was highlighted also in the discussions. From the industry perspective attention was brought on the importance of finding the optimum between hydropeaking mitigation and hydropower flexibility while from the university side, the focus on future research needs was made clear. While negative ecological impacts from hydropower on fish are highly pronounced across Europe, the closing panel debate emphasized that scientific researchers, water managers and the hydropower industry must establish better long-term relationships. This can mitigate these impacts in order to ensure that environmental, ecological and societal issues are addressed and to establish a continuous knowledge exchange basis, where research and innovation goes hand in hand with site and species-specific implementation

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and improvement. One important outcome of such collaboration could be the establishment of common criteria for all the different parameters to be assessed within the hydropower and fish context.

Judged by the large number of delegates and presentations, and the multidisciplinary outcomes of the debates and discussions, the workshop organizers (IEA Hydro and EC DG RTD) had the clear impression that the event represented a valuable scene for knowledge and experience exchange. The mutual beneficial interaction between research, the hydropower value chain, public bodies and society can maximize the outcomes for reaching an optimum in socioeconomic and environmental sustainability. The IEA Hydro, Annex XIII, titled Hydropower and Fish (Figure 2), is currently developing a "Roadmap for sustainable fish populations in regulated rivers" and messages and output from the workshop will be included in this report. There is an apparent goal that the Roadmap, in return, can serve as a valuable guideline for future environmentally sound hydropower production and development.

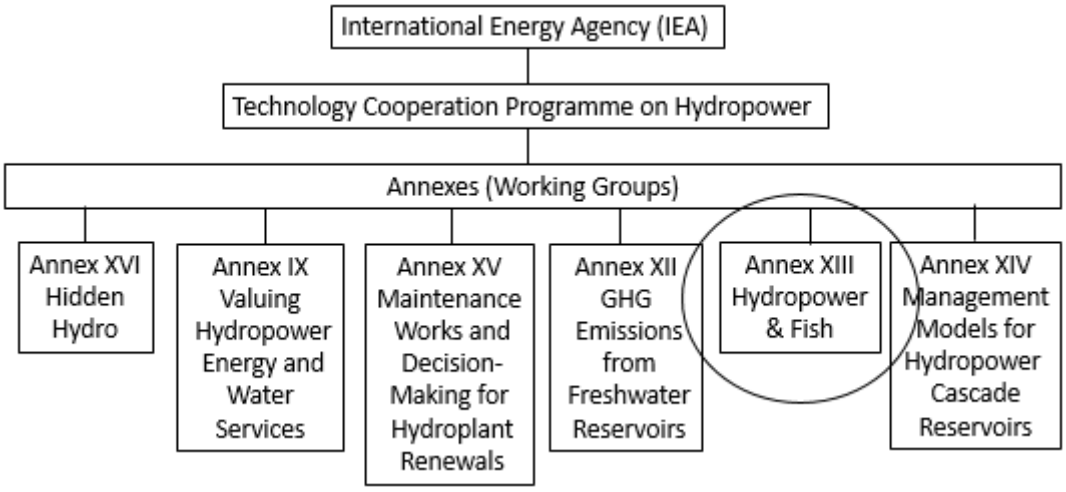

Figure 2. The organization plan of IEA Hydro, with annex XIII inside the circle as one of six working groups.

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Summary and workshop messages

After the panel discussion, and as an endpoint, the organizers (the authors of the present paper) made a wrap-up of the workshop. The goal of this summary was to point out research gaps and needs and to communicate the main messages from the presentations and discussions. This included the following main points:

1. **Optimization of both hydropower production and fish sustainability requires a balanced approach and collaboration between industry, science, society and water management.**

- Hydropower production with its impacts on fish will remain an important renewable source of energy in Europe and worldwide also in the future
- Optimization requires an integrated approach taking into consideration of all relevant factors (see figure 1).

2. **A shift towards more sustainable river ecology beyond fish, and a changing use of hydropower production facilities requires a systemic research approach, for building up a efficient knowledge basis, including research on:**

- Consequences of rapid changes of river flow (hydropeaking/balancing power)
- Sediment transport in larger river systems
- Two-way fish migration facilities and monitoring of long- and short range migrating fishes
- Alien species, biodiversity

3. **Research on hydropower and fish is multidisciplinary, and the good solutions can only be achieved when a suite of scientific topics are included.**

- Need to advance from single topic research and models to holistic models and interdisciplinary research and system approaches

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Interdisciplinary information exchange to foster synergies between isolated research areas and between different research programmes.

4. **Knowledge sharing, and comparative analysis of different River Basin Systems is paramount.**

- Common and standardized protocols and indices should be developed, such as characteristics for hydromorphology, water flow, species comparison as well as data collection and modelling methodologies
    - Synergies can be reached by European/international information sharing and by contributing isolated or national research into international research programmes.

Signals and demands from the audience and speakers suggested that the workshop should be followed up by future workshops, aiming at a continuation of the discussions and knowledge exchange. In particular, it was regarded as a large advantage that the event covered a total environment approach where all the spheres involved were represented and the three dimensions of sustainability were displayed.

Acknowledgements:

The authors would like to thank all the speakers and persons involved in the preparation of the workshop making it a successful event and to Niels Nielsen, Secretary of IEA Hydro for valuable comments to the manuscript and Raimund Mair at the European Commission, DG ENV for fruitful discussions on hydropower research and innovation in the context of environmental policy.

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